NAMRL SR87-1

PRACTICE REQUIREMENTS FOR COGNITIVE AND MANUAL TASKS ON THE NEC 8201A MICROPROCESSOR

Charles A. DeJohn and Larry Hochhaus

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NAVAL AEROSPACE MEDICAL RESEARCH LABORATORY
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ERRATA

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1. Page 3, Paragraph 4, Line 8:

   "105 min" should read "120 min"

2. Page 5, Table 2:

   Table Title, Line 2:

   "STERNB" should read "REACT"
   "CODSUB" should read "STERNB"

   Column Headings:

   "STERNB" should read "REACT"
   "CODSUB" should read "STERNB"

3. Page 5, Table 3:

   Table Title:

   "REACT" should read "CODSUB"

   Column Heading:

   "REACT" should read "CODSUB"

4. Page 6, Last Paragraph, Line 5:

   "PTRNC" should read "PATRNC"

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Practice requirements for tasks in the Essex Corporation automated portable test system were evaluated by having 16 naval personnel complete 12 sessions of a 6-minute battery over a 4-day period. Five cognitive tasks and three finger-tapping tests showed significant improvements in number correct, decision time, and number of alternations for varying numbers of sessions, depending on task and performance measure. Number of errors generally did not show significant changes across sessions. Results show six sessions were needed for all tasks and measures to reach asymptote levels.

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SUMMARY PAGE

THE PROBLEM

As part of a sustained operations (SUSOPS) research project, we had an opportunity to collect performance data on navy aircrew flying a practice long-range strike mission from an aircraft carrier. Essex Corporation NEC 8102A microprocessors were selected to collect the cognitive performance data because the units are small and easily transportable. The microprocessors were programmed with a performance assessment battery (PAB) consisting of five cognitive tasks and three finger-tapping tasks. The purpose of this investigation was to determine the number of practice sessions required to eliminate learning effects and stabilize performance.

FINDINGS

1. The five cognitive tasks showed significant improvement in the number correct across sessions.

2. The reaction time showed significant improvement across sessions in the logical reasoning, short-term memory, code substitution, and four choice reaction time tasks, but not in the pattern recognition task.

3. The number of errors for the cognitive tasks did not show significant changes across sessions.

4. The three finger-tapping tasks showed significant improvement in the number of alterations across sessions.

5. Six sessions were needed for all tasks to reach asymptotic levels.

RECOMMENDATIONS

We recommend that at least six practice sessions be used to train of subjects on this PAB to eliminate learning effects and stabilize performance.

ACKNOWLEDGMENTS

We would like to acknowledge the cooperation of the U. S. Air Force, School of Aerospace Medicine, Brooks Air Force Base, TX, for their loan of the NEC-8201A microprocessors and for their programming support.

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INTRODUCTION

The purpose of the present study was to prepare for the cognitive evaluation portion of a field investigation into the effects of sustained flight operations on naval aircrews. The planned field experiment involved a comparison of cognitive and manual skills before and after an extended over water training mission. The five cognitive and three manual tasks to be evaluated were programmed as a performance assessment battery (PAB) on Essex Corporation NEC 8201A microprocessors.

We sought information concerning the number of prior practice sessions needed to allow a valid comparison of preflight and postflight performance levels on the tasks. The present investigation was undertaken to accomplish three goals: 1) to provide practice in administration of the computer test battery, 2) to allow evaluation and possible correction of the computer programs and scoring procedures, and 3) to evaluate the effects of practice across 12 successive administrations of the test battery.

METHOD

SUBJECTS

The 16 participants were 11 pre-flight-training male ensigns stationed at the Naval Aerospace Medical Research Laboratory (NAMRL) with a mean age of 22.45 years (SD = 1.04) and 5 female student assistants, secretaries, and staff members at NAMRL with a mean age of 21.80 (SD = 2.39). The ensigns were concurrently under a regime of physical exercise training and were in excellent physical condition. One male and one female were left-handed; their scores were not analyzed separately, however.

COMPUTER TESTS

The PAB required about 6 min of testing per session and consisted of abbreviated forms of pattern matching, finger-tapping, grammatical reasoning, Sternberg recognition memory, code substitution, and four-choice reaction time tests, in that order. Visual displays were presented on a liquid crystal screen, which was adjusted to maximum contrast by each participant prior to the start of each session. To collect the data, two identical Nippon Electronic Corporation (NEC) computers were placed at two desks in the same room. The desks were separated by an 8 ft x 5 ft x 2 in sound-deadening partition. In these tasks, the number correct, the number of errors, and the mean correct reaction time were recorded and printed following each session. In the finger-tapping tasks, however, the recorded measure was the number of alternations. A brief description of each test follows:

Pattern Recognition (PATRNC)

Participants were successively presented two patterns of asterisks and asked to type the "S" (same) or "D" (different) keys with their left hand.

Tapping Tests

The participant was asked to alternatively press two keys as rapidly as possible with different pairs of fingers. Two separate testing periods were presented for each test. In the analyses that follow, the mean of the two similar tests was computed for each session.

1. Preferred-hand (PHTAP). The keys pressed were "K" and "L" (right-handed participants) or "S" and "D" (left-handed subjects).

2. Two-fingered (TFTAP). All participants alternatively pressed the "S" and "L" keys.

3. Non-preferred hand (NTAP). The keys pressed were "S" and "D" (right-handed) or "K" and "L" (left-handed participants).

Reasoning (REASON)

In the Baddeley grammatical reasoning test, participants compared a sentence (e.g., "A IS LED BY B" or "A LEADS B") and a picture of two letters (either AB or BA) and pressed the "T" (true) or "F" (false) keys with their right hand to indicate matches and mismatches, respectively.

Sternberg (STERNBERG)

This test was actually a disjointed reaction time test because only a memory set size of four was used; a group of four numbers was displayed for approximately 1 s. Two seconds later, one digit was displayed. Participants were asked to press "T" (probe digit was in the memory set) or "F" (probe digit was not in the memory set) with their right hand. A series of five probes was shown, then another four memory digits were presented, followed by another five probes, and so on in repeating cycles.

Code Substitution (CODSUB)

This test was similar to the digit-symbol test of the Weschsler Adult Intelligence Scale (WAIS). A group of nine letters was displayed with associated numbers at the top of the screen, as follows:

F	X	S	M	V	L	U	R	C
(3)	(4)	(9)	(8)	(5)	(6)	(2)	(1)	(7)

Below this master list, two rows of letters and blank parentheses were displayed, as shown below:

R	F	R	M	C	S	X	L	V
( )	( )	( )	( )	( )	( )	( )	( )	( )
X	M	V	F	S	C	L	C	U
( )	( )	( )	( )	( )	( )	( )	( )	( )

Participants were asked to fill in the blank parentheses with the matching numbers from code at the top of the screen, as shown:

R	F	R	M	C	S	X	L	V
(1)	(3)	(1)	(8)	(7)	(9)	(4)	(6)	(5)

and so on.

Four-choice Reaction Test (REACT)

Participants saw four checkered blocks at the bottom of the screen, one over each of the oblong keys labeled f.2 through f. 5 at the top of the keyboard. After 1 s, the four blocks disappeared and were replaced by a checkered block over one of the four oblong keys. When the participant responded by pressing the appropriate key, a checkered block appeared over another key (or at times, over the same key).

PROCEDURE

Eight of the participants, seven males and one female, were tested four times a day for 3 days. The remaining eight participants, four males and four females, were tested three times a day for 4 days. All participants completed 12, 6-min computer test sessions. Within each session, the order of testing was PATRNC, REASON, PHTAP-first test, PHTAP-second test, TFTAP-first test, TFTAP-second test, NPTAP-first test, NPTAP-second test, STERNB, CODSUB, and REACT. Test sessions were scheduled 105 min apart. All testing was accomplished between 0900 and 1600. The entire experiment required 4 days to complete.

RESULTS

Due to an error in the computer program, the number of alternations for the three tapping tests was not saved or printed for the first session for all 12 participants. The program was corrected, and the tapping data of sessions 2-12 were saved and printed. No other procedural or computer program factors interfered with the tests. As indicated, the mean number of alternations for each pair of identical finger-tapping tasks was computed for each subject for each session prior to analysis of the session effects.

To evaluate overall session differences, a single-factor, repeated measures analysis of variance was carried out on each dependent variable for each task. The session means and resulting F values have 11 and 165 degrees of freedom except those associated with the tapping tests, which have 11 and 150 degrees of freedom.

The results of the overall F-tests are easily summarized. The number of errors did not show significant session effects for any of the five cognitive tasks (Tables 1-3). The number of alternations (Table 4) also did not show significant session differences (sessions 2-12) for each of the three tapping tasks. For each cognitive task, however, the number of correct responses showed highly significant ($p < .001$) differences between sessions 1-12. Reaction time measures showed significant between-session differences at the $p < .05$ level for the REASON task and at the $p < .001$ level for the STERNB, CODSUB, and REACT tasks; but did not differ across sessions for the PATRNC task.

TABLE 1. Mean Number Correct, Number Errors, and Mean Correct Reaction Time (RT) for PATRNC and REASON Tasks. Asterisks indicate significant difference from session 12, using Dennett's test.

	PATRNC			REASON		
Session	Number correct	Number errors	RT	Number correct	Number errors	RT
1	30.81*	7.30	774	13.12*	3.60	3073
2	34.00*	6.13	788*	13.37*	5.17	2896
3	37.43*	6.25	713	13.06*	5.43	2828
4	40.75*	5.00	745	14.00	4.72	2795
5	39.62*	5.79	745	15.37	3.81	2948
6	40.25*	6.13	733	14.12	4.45	2920
7	43.93	4.84	733	15.00	4.45	2737
8	42.75	5.98	744	15.18	4.60	2716
9	43.00	5.25	730	15.56	4.40	2670
10	44.93	4.40	717	16.50	4.33	2599
11	45.37	3.27	736	17.00	3.80	2614
12	45.37	5.79	700	16.18	4.50	2706
	$F = 19.04$	1.90	1.66	4.62	.99	2.28
	$p < .001$	$> .05$	$> .05$	$< .001$	$> .05$	$< .05$

TABLE 2. Mean Number Correct, Number Errors, and Mean Correct Reaction Time (RT) for STERNB and CODSUB Tasks. Asterisks indicate significant difference from session 12, using Dennett's test.

	STERNB			CODSUB		
Session	Number correct	Number errors	RT	Number correct	Number errors	RT
1	88.43*	2.32	499*	26.50*	1.42	833*
2	90.68*	3.45	476	26.06	1.45	861*
3	97.75	2.24*	470	27.43	1.80	762*
4	94.56	3.31	452	27.12	2.08	766*
5	95.68	2.71	448	28.00	1.98	725*
6	95.18	3.01	450	28.25	1.62	709
7	97.12	2.91	437	28.50	1.68	709
8	96.00	2.67	450	28.81	1.36	701
9	96.25	3.21	445	28.43	1.99	680
10	95.56	2.29	451	28.75	1.53	689
11	94.56	2.82	431	28.25	2.19	681
12	95.12	4.48	444	30.00	1.17	631
	F = 5.11	1.21	3.16	5.82	1.04	11.95
	p <.001	> .05	< .001	< .001	> .05	< .001

TABLE 3. Mean Number Correct, Number Errors, and Mean Correct Reaction Time (RT) for REACT Task. Asterisks indicate significant difference from session 12, using Dennett's test.

	REACT		
Session	Number correct	Number errors	RT
1	22.12*	1.84	2028*
2	23.93*	3.25	1885*
3	26.81*	1.53	1923*
4	27.81*	1.37	1850*
5	27.87	2.74	1759
6	29.68	1.63	1713
7	30.87	1.63	1638
8	29.06	1.21	1722
9	31.31	1.35	1633
10	29.93	1.89	1646
11	30.87	1.53	1552
12	31.93	1.11	1616
	F = 8.60	1.06	8.36
	p < .001	> .05	< .001

TABLE 4. Mean Number of Alternations for Three Finger-Tapping Tasks. Asterisks indicate significant difference from session 12, using Dennett's test.

	Number of Alternations		
SESSION	PHTAP	TFTAP	NPTAP
1			
2	39.43*	40.78*	37.43*
3	41.46*	42.37	37.87
4	42.06	43.00	38.43
5	42.21	43.15	38.09
6	41.43	42.00	38.81
7	41.40	43.37	38.37
8	42.71	42.59	38.62
9	42.03	44.06	38.68
10	42.28	42.93	37.93
11	42.00	42.96	37.87
12	50.46	42.28	39.46
	F = 1.21	.66	.59
	p > .05	> .05	> .05

To evaluate the effects of learning and practice in these tasks, specific comparisons between session means were required. To avoid the many possible comparisons among 12 session means, we compared the various session means to an index of final asymptotic performance level, namely, the mean score on session 12 for the measure under consideration. Dennett's test for several contrasts involving a control mean (3) was ideally suited to this purpose. This procedure allowed comparison of each session mean to the mean of the final session while protecting against an excessive number of type I errors of inference due to the number of tests involved. Because these tests were planned before the data were collected, a significant overall sessions effect was not required before applying Dennett's procedure (3). Consequently, the Dennett technique was applied to each measure of every task.

The results of the Dennett tests are indicated by asterisks in Tables 1-4. Hence, each mean marked with an asterisk differs significantly from the mean of session 12 for that measure. To summarize, number correct performance did not differ from the session 12 level after 6, 3, 2, 1, and 4 sessions, respectively, for the PTRNC, REASON, STERNB, CODSUB, and REACT tasks. Similarly, no differences in reaction time performance relative to session 12 were noted after 2, 0, 1, 5, and 4 sessions for the five respectively ordered tasks. None of the number of error session means differed from the session 12 level for any cognitive task except the mean of session 3 for the STERNB error measure. In tapping tasks, number of alternations did not differ from the session 12 level after 2, 1, and 1 sessions, respectively, for PHTAP, TFTAP, and NPTAP tests.

DISCUSSION

Examination of performance trends across sessions (Tables 1-4) supports a number of generalizations concerning the tasks involved. First, for each of the cognitive tasks, we found no significant differences between sessions in number of errors. Also, for all cognitive tasks, the number correct measure showed highly significant effects of practice. Increases in the number of correct responses were observed across sessions for each test. In general, the greatest increases were noted in the first few sessions.

Specific comparisons using Dennett's procedure for contrasting several means with a single control mean (session 12 performance level) indicate that significant improvements in number correct are limited to the first six sessions for the cognitive tasks. The data reveal some task differences in this matter. For example, four to six sessions were needed for number correct performance to stabilize in the PATRNC, CODSUB, and REACT tasks, while the REASON and STERNB tasks needed only two or three sessions to reach asymptotic levels.

Reaction time measures showed highly significant ($p < .001$) decreases in decision times across sessions for STERNB, CODSUB, and REACT tasks and a marginally significant ($p < .05$) difference for the REASON task. The PATRNC did not show significant session differences in decision times. Dennett tests applied to reaction time measures also showed that greatest learning occurred in early sessions. Variously, one to five sessions were needed before session means consistently failed to show significant differences from the final, session 12 decision time level.

Number of alternations measures in the three finger-tapping tasks failed to show significant session differences. Planned individual mean comparisons, however, indicated the mean of session 2 (TFTAP and NPTAP), or the means of both sessions 2 and 3 (PHTAP), or the means of both sessions 2 and 3 (PHTAP) differed reliably from the final session 12 alternation level.

In general, these analyses indicate the need for six sessions on the test battery to be assured that further significant improvements in performance (number correct, decision time, number of alternations) are unlikely to occur with additional practice on the tasks. We recognize, however, that exigencies of field testing situations may require application of fewer than six practice sessions before beginning experimental comparisons. If practice on the battery is limited, however, simple preflight versus postflight comparisons might fail to show significant differences due to nonspecific learning effects produced by practice and experience within the preflight test session. Possibly, the present data could be used to adjust for such effects when these cannot be avoided by giving participants sufficient practice prior to the task.

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